

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

9847-0036-6X PCT

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09 / 508685

INTERNATIONAL APPLICATION NO.  
PCT/SE98/01741INTERNATIONAL FILING DATE  
29 SEPTEMBER 1998PRIORITY DATE CLAIMED  
30 SEPTEMBER 1997

## TITLE OF INVENTION

A ROTARY ELECTRIC MACHINE

## APPLICANT(S) FOR DO/EO/US

Erland SORENSEN, et al

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

## Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.  
A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☒ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☐ Certificate of Mailing by Express Mail
19. ☒ Other items or information:

## Notice of Priority

Marked-up Specification

Citation List-Alternate Form PTO-1449

Response to Petition Under 37 CFR 1.182

Request For Consideration of Documents Cited in International Search Report

08 MAR 2000  
PCT/PTO

U.S. APPLICATION NO. (37 CFR 1.53) <b>09/508685</b>	INTERNATIONAL APPLICATION NO. <b>PCT/SE98/01741</b>	ATTORNEY'S DOCKET NUMBER <b>9847-0036-6X PCT</b>
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20. The following fees are submitted:

**BASIC NATIONAL FEE ( 37 CFR 1.492 (a) (1) - (5) ) :**

- ☐ Search Report has been prepared by the EPO or JPO ..... **\$840.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... **\$670.00**
- ☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) ..... **\$760.00**
- ☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... **\$970.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) ..... **\$96.00**

**ENTER APPROPRIATE BASIC FEE AMOUNT =****\$970.00****CALCULATIONS PTO USE ONLY****\$130.00**

Surcharge of **\$130.00** for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)). ☐ 20 ☒ 30

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	19 - 20 =	0	x \$18.00
Independent claims	5 - 3 =	2	x \$78.00

**\$0.00****\$156.00**Multiple Dependent Claims (check if applicable). ☐**\$0.00****TOTAL OF ABOVE CALCULATIONS =****\$1,256.00**

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐

**\$0.00****SUBTOTAL =****\$1,256.00**

Processing fee of **\$130.00** for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)). ☐ 20 ☐ 30 +

**\$0.00****TOTAL NATIONAL FEE =****\$1,256.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☐

**\$0.00****TOTAL FEES ENCLOSED =****\$1,256.00****Amount to be:****\$****charged****\$**

☒ A check in the amount of **\$1,256.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \_\_\_\_\_ to cover the above fees.  
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

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REGISTRATION NUMBER

DATE

**March 28, 2000**

09/508685

416 Rec'd PCT/PTO 28 MAR 2000

9847-036-6X PCT  
ENKEL 8295

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :  
ERLAND SOERENSEN ET AL : ATTN: APPLICATION DIVISION  
SERIAL NO: NEW APPLICATION :  
(Based on PCT NO:SE98/01741)  
FILED: HEREWITH :  
FOR: A ROTARY ELECTRIC :  
MACHINE

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS  
WASHINGTON, D.C. 20231

SIR:

Prior to examination on the merits, please amend the above-identified patent  
application as follows:

IN THE CLAIMS

Please cancel without prejudice or disclaimer Claims 1-18.

Please add new Claims 19-37 as follows:

--19. An alternating current rotary electric machine configured to be connected  
directly to a distribution or transmission network, comprising:  
an electric winding having  
an electric conductor,

a first layer that exhibits semiconducting properties and surrounds the electric conductor,

a solid insulating layer surrounding the first layer, and

a second layer that exhibits semiconducting properties and surrounds the insulating layer; and

a brushless excitation system, switchable between positive and negative excitation modes of operating, configured to excite the alternating current rotary electric machine.

20. A machine as claimed in claim 19, wherein:

a potential on the first layer is substantially equal to a potential on the conductor.

21. A machine as claimed in claim 19, wherein:

the second layer is arranged to form a substantially equipotential surface surrounding the conductor.

22. A machine as claimed in claim 21, wherein:

the second layer is connected to a source of a predetermined potential.

23. A machine as claimed in claim 22, wherein:

said predetermined potential is earth potential.

24. A machine as claimed in claim 19, wherein:

at least two adjacent layers of the electric winding have substantially equally large coefficients of thermal expansion.

25. A machine as claimed in claim 19, wherein:

the conductor comprises a number of strands, at least some of which are in electric contact with each other.

26. A machine as claimed in claim 19, wherein:

each of said first layer, said insulation layer and said second layer is firmly joined to adjacent layers along respective entire contact surfaces.

27. A machine as claimed in claim 26, wherein:

said layers are arranged to adhere to each other even when the electric winding is bent.

28. An alternating current rotary electric machine configured to be connected directly to a distribution or transmission network, comprising:

a magnetic core;

an electric winding formed from a cable having

a current-carrying conductor having a number of strands,

an inner semiconducting layer arranged around the current-carrying conductor,

an insulating layer of solid insulating material arranged around said inner semiconducting layer, and

an outer semiconducting layer arranged around the insulating layer;

and

a brushless excitation system, switchable between positive and negative excitation modes of operating, configured to excite the alternating current rotary electric machine.

29. A machine as claimed in claim 28, wherein:

said cable comprises at least one of a metal screen and a sheath.

30. A machine as claimed in claim 28, wherein:

the brushless excitation system comprises

two controllable antiparallel-connected current converter devices  
configured to feed a field winding machine,  
at least one of a two-way field over-voltage protection mechanism and  
a discharge circuit connected across the field winding, and  
control equipment configured to control current converters and a field  
over-voltage protection mechanism or discharge circuit.

31. A machine as claimed in claim 30, wherein:

the control equipment is configured to change a polarity of the current converters for  
switching a direction of the excitation current from the excitation system, and

the control equipment configured to cause the over-voltage protection mechanism to  
be temporarily connected at transition from one to the other current direction.

32. A machine as claimed in claim 31 wherein:

at least one of the over-voltage protection mechanism and the discharge circuit  
includes a two-way thyristor discharge circuit.

33. A machine as claimed in claim 32, wherein:

at least one of the activated over-voltage protection mechanism and the discharge  
circuit when activated is resettable by control of conducting converter devices to temporary  
or pulse-formed change of polarity modes of operation.

34. A machine as claimed in claim 32, wherein:

at least one of the activated over-voltage protection mechanism and the discharge  
circuit when activated is resettable by extinguishable semiconductor elements.

35. An electric power plant comprising:

an alternating current rotary electric machine configured to be connected directly to a  
distribution or transmission network, having an electric winding with

an electric conductor,  
a first layer that exhibits semiconducting properties and surrounds the electric conductor,  
a solid insulating layer surrounding the first layer, and  
a second layer that exhibits semiconducting properties and surrounds the insulating layer; and  
a brushless excitation system, switchable between positive and negative excitation modes of operating, configured to excite the alternating current rotary electric machine.

36. A method of exciting a rotary electric machine with both positive and negative excitation current directions, comprising steps of:

temporarily connecting at least one of a two-way field over-voltage protection mechanism and a two-way discharge circuit across field windings of the machine during an excitation operation; and

switching between the positive and negative excitation current directions.

37. An alternating current rotary electric machine with both positive and negative excitation current directions and being configured to be connected directly to a distribution or transmission network, comprising:

field windings;

means for protecting said alternating current rotary electric machine for an over-voltage protection event;

means for temporarily connecting said means for protecting across the field windings during an excitation operation; and

means for switching between the positive and negative excitation current directions.--

IN THE ABSTRACT OF THE DISCLOSURE

After the last page, please insert the following Abstract of the Disclosure:



## --ABSTRACT OF THE DISCLOSURE

A rotary electric machine of alternating current type designed to be connected directly to a distribution or transmission network having at least one electric winding. The winding includes at least one electric conductor, a first layer with semiconducting properties surrounding the conductor, a solid insulating layer surrounding the first layer and a second layer with semiconducting properties surrounding the insulating layer. A brushless excitation system, switchable between positive and negative excitation, is also arranged for excitation of the machine. An electric power plant includes such a rotary electric machine. In a method of exciting a rotary electric machine with both positive and negative excitation current direction, a two-way field over-voltage protection mechanism or a two-way discharge circuit is connected temporarily across the field winding of the machine.--

## REMARKS

Favorable consideration of this application as presently amended and in light of the following discussion is respectfully requested. Claims 19-37 are pending, Claims 1-18 having been cancelled without prejudice or disclaimer and Claims 19-37 having been added by way of the present amendment. New Claims 19-37 find support in original Claims 1-18 and thus no new matter is added. Claim 37 has been added to include claim elements that invoke interpretation under 35 U.S.C. §112, sixth paragraph. An Abstract has been added, consistent with the U.S. patent drafting procedure.

Because several amendments have been made to the specification, consistent with U.S. patent drafting practice, a substitute specification is filed herewith in addition to a marked-up copy of the original application. Please enter this substitute specification. To the extent any changes made by the substitute specification are deemed to be substantively inconsistent with the originally filed specification, these changes should be construed as typographical errors and the language included in the originally filed specification should be construed as containing the controlling language.

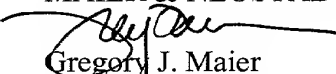
Because several amendments have been made to the specification, consistent with U.S. patent drafting practice, a substitute specification is filed herewith in addition to a marked-up copy of the original application. Please enter this substitute specification. To the extent any changes made by the substitute specification are deemed to be substantively inconsistent with the originally filed specification, these changes should be construed as typographical errors and the language included in the originally filed PCT specification should be construed as containing the controlling language. The present document is one of a set of patent applications containing related technology as was discussed in "Response to Petition Under 37 C.F.R. §1.182 Seeking Special Treatment Relating to an Electronic Search

Tool, and Decision on Petition Under 37 C.F.R. §1.183 Seeking Waiver of Requirements Under 37 C.F.R. §1.98, filed in the holding application (U.S. Patent Application No. 09/147,325). Consistent with this decision, a copy of the decision is filed herewith. Also, an Information Disclosure Statement is filed herewith including a 1449 form with references that are included as part of the specially created official digest in class 174. It is believed that submission of these materials and the preference reference to the holding application (serial no. 09/147,325) is sufficient for the present Examiner to consider the references in the holding application, consistent with the decision.

In view of the present amendment and in light of the foregoing comments, an examination on the merits is believed to be in order and an early and favorable action is respectfully requested.

Respectfully submitted,

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SUBSTITUTE SPECIFICATION

9847-0036-6X PCT  
ENKEL 8295

TITLE OF THE INVENTION

A ROTARY ELECTRIC MACHINE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a rotary electric machine of alternating current type designed to be connected directly to a distribution or transmission network and having at least one electric winding. The invention also relates to an electric power plant having such an electric machine, and also to a method of exciting a rotary electric machine.

Discussion of the Background

The rotary electric machine according to the invention may be a synchronous machine, dual-fed machine, external pole machine or synchronous flow machine.

To connect machines of this type to distribution or transmission networks, in the following referred to as power networks, transformers have hitherto been used to step up the voltage to network level, i.e. to the range of 130-400 kV.

Generators having a rated voltage of up to 36 kV are described by Paul R. Siedler "36 kV Generators Arise from Insulation Research", Electrical World, 15 October 1932, pages 524-527. These generators have windings of high-voltage cable in which the insulation is divided into different layers with different dielectric constants. The insulating material used is made of various combinations of the three components mica-foil mica, varnish and paper.

It has now been found that, by manufacturing the above-mentioned winding of the electric machine from an insulated electric high-voltage conductor with a solid insulation of a type similar to that used in cables for power transmission, the machine voltage can be increased to such levels that the machine can be connected directly to any power network without the use of intermediate transformers. A typical operating range for these machines is 30 to 800 kV.

Today, static exciters or brushless exciters with rotating diode rectifier bridges are used in rotary electric machines. The excitation equipment is frequently required to be able to produce a peak voltage and peak current of 1.5 to 3 times greater than equivalent

magnitudes in the case of rated load excitation for the machine in question, for a duration of 10-30 seconds. The excitation equipment is also be able to produce a field current equivalent to the rated load excitation current for 25% voltage on the stator terminal of the machine. The excitation system is preferably "maintenance free", i.e. an excitation system without slip rings. The response and transient times at network disturbances are rapid, i.e. the excitation equipment is able to generate both positive and negative field voltage. In the case of synchronous compensators, the excitation system is generally able to produce both positive and negative field current and demands for peak voltage factors greater than 3 times the rated load excitation voltage may occur.

Brushless exciters eliminate the problems of dirt from carbon dust from brushes and slip rings. However, brushless exciters in accordance with known technology exhibit poorer control performance than static exciters.

An object of the present invention is thus to provide a rotary electric machine that can be connected directly to a power network and that is provided with a "maintenance free" excitation system with improved control performance, and an electric power plant having such an electric machine, as well as to propose a method for excitation of a rotary electric machine.

### DESCRIPTION OF THE INVENTION

This object is achieved with a rotary electric machine of the type described in the introduction, having the characterizing features discussed herein.

The insulating conductor or high-voltage cable used in the present invention is flexible and is of the type described in more detail in WO 97/45919 and WO 97/45847. The insulated conductor or cable is described further in WO 97/45918, WO 97/45930 and WO 97/45931.

Thus, in the device in accordance with the invention the windings are preferably of a type corresponding to cables having solid, extruded insulation, like those currently used for power distribution, such as XLPE-cables or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strands, an inner semi-conducting layer surrounding the conductor, a solid insulating layer surrounding this semiconducting layer and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this context since the technology for the device

according to the invention is based primarily on winding systems in which the winding is formed from cables which are bent during assembly. The flexibility of a XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable 30 mm in diameter, and a radius of curvature of approximately 65 cm for a cable 80 mm in diameter.

5 In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature of the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

The winding should be constructed to retain its properties even when it is bent and when it is subjected to thermal or mechanical stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In a XLPE-cable, for instance, the insulating layer is made of cross-linked, low-density polyethylene, and the semiconducting layers is made of polyethylene with soot and metal particles mixed in. Changes in volume as a result of temperature fluctuations are completely absorbed as changes in the radius of the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, the radial expansion can take place without the adhesion between the layers being lost.

20 The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having a resistivity within the range of  $10^{-1}$ - $10^6$  ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of the invention.

25 The insulating layer may be made of, for example, of a solid thermoplastic material such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentane (PMP), cross-linked materials such as cross-linked polyethylene (XLPE), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

The inner and outer semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

30 The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by whether soot or metal powder is mixed in or not -

at least in the proportions required to achieve the conductivity necessary according to the invention. The insulating layer and the semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymers/nitrile rubber, butylmp polyethylene,  
5 ethyleneacrylate-copolymers and ethylene-ethyl-acrylate copolymers may also constitute suitable polymers for the semiconducting layers.

Even when different types of material are used as base in the various layers, it is desirable that their coefficients of thermal expansion are of the same order of magnitude. This is the case with the combination of the materials listed above.

10 The materials listed above have relatively good elasticity, with an E-modulus of  $E < 500$  MPa, preferably  $< 200$  MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks or other damage appear and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion  
15 between the layers is at least of the same magnitude as the weakest of the materials.

The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently large to contain the electrical field in the cable, but sufficiently small not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.  
20

Thus, each of the two semiconducting layers essentially constitutes one equipotential surface, and the winding with these layers will substantially enclose the electrical field within it.

25 There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

By providing the electric machine in question with a brushless excitation system switchable between positive and negative excitation, a "maintenance free" system is obtained having rapid response and transient times at network disturbances, for instance, since the excitation system is able to generate both positive and negative field voltage and thus  
30 positive and negative field current.

According to an advantageous embodiment of the machine in accordance with the

invention, the excitation system comprises two controllable antiparallel-connected current converter devices for feeding the field winding of the alternating current machine, a two-way field over-voltage protection mechanism or discharge circuit connected across the field winding, and also control equipment for controlling the current converters and over-voltage protection means or discharge circuit. This is a simple construction requiring no galvanically separated supply sources and current-limiting reactances and no separate short-circuiting devices for extinguishing conducting thyristors. The excitation system is also well suited for synchronous machines such as synchronous compensators. The present invention thus exploits the ability offered by semiconductor technology to temporarily change the polarity in a simple manner, which facilitates rapid commutation of the field current from static current converter bridge to short-circuiting circuit and vice versa when a change of current direction is required in the field circuit of the machine.

#### BRIEF DESCRIPTION OF THE DRAWINGS

To explain the invention more clearly embodiments of the machine in accordance with the invention, selected by way of example, will now be described in more detail with reference to the accompanying drawings, in which

Figure 1 shows the insulated cable used in the machine in accordance with the invention,

Figure 2 shows a circuit diagram of the excitation system in the machine in accordance with the invention, and

Figures 3a-f show the voltage and current variation upon bridge switching in the excitation system shown in Figure 2.

#### DESCRIPTION OF A PREFERRED EMBODIMENT

Figure 1 shows a cross section through an insulated conductor 11 intended for use in the windings of the machine in accordance with the present invention.

The insulated conductor 11 thus has a number of strands 35 having circular cross section and consisting of copper (Cu), for instance. These strands 35 are arranged in the middle of the insulated conductor 11. A first semiconducting layer 13 is arranged around the strands 35. An insulating layer 37, e.g. XLPE insulation, is arranged around the first semiconducting layer 13. A second semiconducting layer 15 is arranged around the



insulating layer 37. The insulated conductor is flexible and retains this property throughout its service life. Said three layers are constructed so that they adhere to each other even when the insulated conductor is bent. The insulated conductor has a diameter within the interval 20-250 mm and a conducting area within the interval 80-3000 mm<sup>2</sup>.

Figure 2 shows a circuit diagram for the excitation system in the machine in accordance with the invention. The field winding 4 of the machine, which may be stationary or rotating, is connected to two antiparallel-connected current converter bridges 1, 2. A two-way over-voltage protection mechanism having two antiparallel-connected thyristors 8, 10 with associated ignition circuits 12, 14, is also provided over the field winding 4.

The current converter bridges 1, 2 are supplied from a source 16 and controlled from a switching logic 18 via control pulse amplifiers 20, 22. A control pulse generator 28 for the current converter bridges 1, 2 in the form of thyristor bridges is also arranged to emit control pulses to the pulse amplifiers 20, 22. Measuring instruments 24, 26 are also arranged to measure the currents IFB1 and IFB2, respectively, from the current converter bridges 1, 2, and transmit the measured results to the switching logic 18 for control purposes. Connection of the thyristors 8, 10 of the over-voltage protection mechanism is also controlled from the switching logic 18 via the ignition circuits 12, 14. The over-voltage protection mechanism is connected to a current-limiting resistor R. In the system with field breakers this resistor R serves as discharge resistor.

The procedure for switching from bridge 1 to bridge 2 is as follows: Initially bridge 1 is assumed to be conducting, which means that the current direction IF through the field winding 4 is positive, see Figures 3a and 3b. The control signal  $U_{st}$ , see Figure 2, to the control pulse generator 28 and the switching logic 18 will be negative, resulting in bias reduction and thus a change of polarity of the bridge 1, see Figure 3a. The time interval for bias change,  $t_2-t_1$  according to Figure 3b, from maximum positive peak voltage to maximum negative peak voltage is approximately 8.3 ms at a frequency of 50 Hz and 6-pulse two-way bridge.

At the time  $t_3$ , when the current  $I_{FB1}$  is still greater than 0, an ignition pulse is transmitted to the discharge thyristor 10 and a blocking signal to the bridge 1. As a result of the free-wheel effect at negative bias, a momentary transmission of excitation current  $I_{FB1}$  to the over-voltage protection circuit is obtained, and the bridge 1 becomes currentless. A signal from the measuring instrument 24 that the bridge 1 is currentless initiates unblocking

of bridge 2 and blocking of the ignition circuit 14 for the thyristor 10. The time interval  $t_4-t_3$  according to Figure 3, i.e. the period from the blocking of bridge 1 until the bridge 2 is connected is approximately 5 ms, see Figure 3. It is apparent from Figure 3d that the current  $I_F$  in the field circuit 4 during this switching interval is maintained as a result of the inductance of the field winding 4. As apparent from Figures 3d and Be, the biased bridge 2 now forces a current  $I_R$ , see Figure 3f, through the thyristor 10 and the current-limiting resistor R, and also a current  $I_F$  through the field winding 4 of the synchronous machine. At the time  $t_5$  the field current  $I_F$  has changed polarity and the discharge thyristor 10 is extinguished through temporary biasing reduction of the bridge 2, i.e. a temporary change in polarity to force a current in the reverse direction of the short-circuiting circuit or the over-voltage protection means.

A suitable choice of current levels for generating blocking and detecting signals ensures that the time interval is brief for connecting the two-way field over-voltage protection means 8, 10, 12, 14 serving as auxiliary circuit or the two-way thyristor discharge circuit.

Switching from negative current direction to positive current direction at a positive control signal occurs in corresponding manner by temporary connection of the thyristor 8 in the over-voltage protection mechanism.

An embodiment of the rotary electric machine in accordance with the invention is described above by way of example. However, several modifications are of course feasible within the scope of the invention. The principle described can thus be used for both stationary and rotating thyristor bridges for exciting synchronous machines or for supplying motors for drive systems. Temporary or pulsed biasing reduction may also be used to reset an activated over-voltage protection mechanism. In a first phase, an over-voltage signal then gives a signal for alarm and resetting the protection means. A continuous error signal after a number of resetting attempts will generate a tripping signal.

The introduction and use of extinguishable semiconductor elements can also shorten the time interval for switching between positive and negative excitation or vice versa. The introduction of extinguishable semiconductor elements in the two-way over-voltage protection makes temporary reversal of the field voltage unnecessary in order to extinguish an activated and conducting semiconductor element.

Obviously, numerous modifications and variations of the present invention are

possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

Claims:

1. A rotary electric machine of alternating current type designed to be connected directly to a distribution or transmission network and comprising at least one electric winding, characterized in that the winding comprises at least one electric conductor, a first layer with semiconducting properties surrounding the conductor, a solid insulating layer surrounding the first layer and a second layer with semiconducting properties surrounding the insulating layer, and also in that a brushless excitation system, switchable between positive and negative excitation, is arranged for excitation of the machine.

2. A machine as claimed in claim 1, characterized in that the potential on the first layer is substantially equal to the potential on the conductor.

3. A machine as claimed in claim 1 or claim 2, characterized in that the second layer is arranged to form a substantially equipotential surface surrounding the conductor.

4. A machine as claimed in claim 3, characterized in that the second layer is connected to a predetermined potential.

5. A machine as claimed in claim 4, characterized in that said predetermined potential is earth potential.

6. A machine as claimed in any of the preceding claims characterized in that at least two adjacent layers of the machine's winding have substantially equally large coefficients of thermal expansion.

7. A machine as claimed in any of the preceding claims characterized in that the conductor comprises a number of strands, at least some of which are in electric contact with each other.

8. A machine as claimed in any of the preceding claims, characterized in that each of said three layers is firmly joined to adjacent layers along substantially its entire contact

surface.

9. A machine as claimed in any of the preceding claims, characterized in that said layers are arranged to adhere to each other even when the insulated conductor is bent.

10. A machine comprising at least one main electric machine of alternating current type designed to be connected directly to a distribution or transmission network and comprising at least one magnetic core and at least one electric winding, characterized in that the winding is formed from a cable comprising one or more current-carrying conductors, each conductor having a number of strands, an inner semiconducting layer arranged around each conductor, an insulating layer of solid insulating material arranged around said inner semiconducting layer, and an outer semiconducting layer arranged around the insulating layer, and in that a brushless excitation system, switchable between positive and negative excitation, is arranged for excitation of the machine.

11. A machine as claimed in claim 10, characterized in that said cable comprises a metal screen or sheath.

12. A machine as claimed in any of the preceding claims, characterized in that the excitation system comprises two controllable antiparallel-connected current converter devices for feeding the field winding of the alternating current machine, a two-way field over-voltage protection means or discharge circuit connected across the field winding, and control equipment for controlling current converters and field over-voltage protection means or discharge circuit.

13. A machine as claimed in claim 12, characterized in that for switching the direction of the excitation current from the excitation system, the control equipment is arranged to change the polarity of the current converters, the control equipment causing the over-voltage protection means to be temporarily connected at transition from one to the other current direction.

14. A machine as claimed in claim 12 or claim 13 characterized in that the over-

voltage protection means or the discharge circuit comprises a two-way thyristor discharge circuit.

15. A machine as claimed in any of claims 12-14, characterized in that an activated over-voltage protection means or discharge circuit can be reset by control of conducting converter devices to temporary or pulse-formed change of polarity.

16. A machine as claimed in any of claims 12-14, characterized in that an activated over-voltage protection means or discharge circuit can be reset by means of extinguishable semiconductor elements.

17. An electric power plant, characterized in that it comprises a rotary electric machine as claimed in any of claims 1-16.

18. A method of exciting a rotary electric machine with both positive and negative excitation current direction, characterized in that a two-way field over-voltage protection means or a two-way discharge circuit is connected temporarily across the field winding of the machine when switching between excitation current directions.

A ROTARY ELECTRIC MACHINETechnical field

The present invention relates to a rotary electric machine of alternating current  
5 type designed to be connected directly to a distribution or transmission network  
and comprising at least one electric winding. The invention also relates to an  
electric power plant comprising such an electric machine, and also to a method of  
exciting a rotary electric machine.

10 Background art

The rotary electric machine according to the invention may be a synchronous ma-  
chine, dual-fed machine, external pole machine or synchronous flow machine.

To connect machines of this type to distribution or transmission networks, in the  
15 following referred to as power networks, transformers have hitherto been used to  
step up the voltage to network level, i.e. to the range of 130-400 kV.

Generators having a rated voltage of up to 36 kV are described by Paul R. Siedler  
"36 kV Generators Arise from Insulation Research", Electrical World, 15 October  
20 1932, pages 524-527. These generators comprise windings of high-voltage cable  
in which the insulation is divided into different layers with different dielectric con-  
stants. The insulating material used consists of various combinations of the three  
components mica-foil mica, varnish and paper.

25 It has now been found that, by manufacturing the above-mentioned winding of the  
electric machine from an insulated electric high-voltage conductor with a solid in-  
sulation of a type similar to that used in cables for power transmission, the ma-  
chine voltage can be increased to such levels that the machine can be connected  
directly to any power network without the use of intermediate transformers. A  
30 typical operating range for these machines is 30 to 800 kV.

Nowadays static exciters or brushless exciters with rotating diode rectifier bridges  
are used in rotary electric machines. The excitation equipment is frequently re-  
quired to be able to produce a peak voltage and peak current of 1.5 to 3 times  
35 greater than equivalent magnitudes in the case of rated load excitation for the  
machine in question, for a duration of 10-30 seconds. The excitation equipment  
shall also be able to produce a field current equivalent to the rated load excitation  
current for 25% voltage on the stator terminal of the machine. The excitation  
system shall preferably be "maintenance free", i.e. an excitation system without

slip rings. The response and transient times at network disturbances shall also be rapid, i.e. the excitation equipment shall be able to generate both positive and negative field voltage. In the case of synchronous compensators, the excitation system shall generally be able to produce both positive and negative field current and demands for peak voltage factors greater than 3 times the rated load excitation voltage may occur.

Brushless exciters eliminate the problems of dirt from carbon dust from brushes and slip rings. However, brushless exciters in accordance with known technology exhibit poorer control performance than static exciters.

The object of the present invention is thus to provide a rotary electric machine that can be connected directly to a power network and that is provided with a "maintenance free" excitation system with improved control performance, and an electric power plant comprising such an electric machine, as well as to propose a method for excitation of a rotary electric machine.

#### Description of the invention

This object is achieved with a rotary electric machine of the type described in the introduction, having the characterizing features of claim 1, an electric power plant in accordance with claim 17 and a method in accordance with claim 18.

The insulating conductor or high-voltage cable used in the present invention is flexible and is of the type described in more detail in WO 97/45919 and WO 97/45847. The insulated conductor or cable is described further in WO 97/45918, WO 97/45930 and WO 97/45931.

Thus, in the device in accordance with the invention the windings are preferably of a type corresponding to cables having solid, extruded insulation, like those currently used for power distribution, such as XLPE-cables or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strands, an inner semi-conducting layer surrounding the conductor, a solid insulating layer surrounding this semiconducting layer and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this context since the technology for the device according to the invention is based primarily on winding systems in which the winding is formed from cables which are bent during assembly. The flexibility of a XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable 30 mm in diameter, and a radius of curvature of approximately 65 cm for a cable 80 mm in



diameter. In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature of the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

- 5 The winding should be constructed to retain its properties even when it is bent and when it is subjected to thermal or mechanical stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In a XLPE-cable, for instance, the insulating layer consists of cross-linked, low-density polyethylene, and the semiconducting layers consist of polyethylene with soot and metal particles mixed in. Changes in volume as a result of temperature fluctuations are completely absorbed as changes in the radius of the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, the radial expansion can take place without the adhesion between the layers being lost.

- The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having a resistivity within the range of  $10^{-1}$ - $10^6$  ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of the invention.

- 25 The insulating layer may consist, for example, of a solid thermoplastic material such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentane (PMP), cross-linked materials such as cross-linked polyethylene (XLPE), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

- 30 The inner and outer semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

- The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by whether soot or metal powder is mixed in or not - at least in the proportions required to achieve the conductivity necessary according to the invention. The insulating layer and the semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymers/nitrile rubber, butylmp polyethylene, ethylene-acrylate-copolymers and ethylene-ethyl-acrylate copolymers may also constitute suitable polymers for the semiconducting layers.

- 5 Even when different types of material are used as base in the various layers, it is desirable that their coefficients of thermal expansion are of the same order of magnitude. This is the case with the combination of the materials listed above.

- The materials listed above have relatively good elasticity, with an E-modulus of  
10  $E < 500$  MPa, preferably  $< 200$  MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks or other damage appear and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion between the layers is at least of the  
15 same magnitude as the weakest of the materials.

- The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently large to contain the electrical field in the cable, but suf-  
20 ficiently small not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.

- Thus, each of the two semiconducting layers essentially constitutes one equipotential surface, and the winding with these layers will substantially enclose the  
25 electrical field within it.

There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

- 30 By providing the electric machine in question with a brushless excitation system switchable between positive and negative excitation, a "maintenance free" system is obtained having rapid response and transient times at network disturbances, for instance, since the excitation system is able to generate both positive and negative field voltage and thus positive and negative field current.

- 35 According to an advantageous embodiment of the machine in accordance with the invention, the excitation system comprises two controllable antiparallel-connected current converter devices for feeding the field winding of the alternating current machine, a two-way field over-voltage protection means or discharge circuit con-

connected across the field winding, and also control equipment for controlling the current converters and over-voltage protection means or discharge circuit. This is a simple construction requiring no galvanically separated supply sources and current-limiting reactances and no separate short-circuiting devices for extinguishing conducting thyristors. The excitation system is also well suited for synchronous machines such as synchronous compensators. The present invention thus exploits the ability offered by semiconductor technology to temporarily change the polarity in a simple manner, which facilitates rapid commutation of the field current from static current converter bridge to short-circuiting circuit and vice versa when a change of current direction is required in the field circuit of the machine.

#### Brief description of the drawings

To explain the invention more clearly embodiments of the machine in accordance with the invention, selected by way of example, will now be described in more detail with reference to the accompanying drawings, in which

- Figure 1 shows the insulated cable used in the machine in accordance with the invention,
- Figure 2 shows a circuit diagram of the excitation system in the machine in accordance with the invention, and
- Figures 3a-f show the voltage and current variation upon bridge switching in the excitation system shown in Figure 2.

#### Description of a preferred embodiment

Figure 1 shows a cross section through an insulated conductor 11 intended for use in the windings of the machine in accordance with the present invention.

The insulated conductor 11 thus comprises a number of strands 35 having circular cross section and consisting of copper (Cu), for instance. These strands 35 are arranged in the middle of the insulated conductor 11. A first semiconducting layer 13 is arranged around the strands 35. An insulating layer 37, e.g. XLPE insulation, is arranged around the first semiconducting layer 13. A second semiconducting layer 15 is arranged around the insulating layer 37. The insulated conductor is flexible and retains this property throughout its service life. Said three layers are constructed so that they adhere to each other even when the insulated conductor is bent. The insulated conductor has a diameter within the interval 20-250 mm and a conducting area within the interval 80-3000 mm<sup>2</sup>.

Figure 2 shows a circuit diagram for the excitation system in the machine in accordance with the invention. The field winding 4 of the machine, which may be stationary or rotating, is connected to two antiparallel-connected current converter bridges 1, 2. A two-way over-voltage protection means comprising two antiparallel-connected thyristors 8, 10 with associated ignition circuits 12, 14, is also provided over the field winding 4.

The current converter bridges 1, 2 are supplied from a source 16 and controlled from a switching logic 18 via control pulse amplifiers 20, 22. A control pulse generator 28 for the current converter bridges 1, 2 in the form of thyristor bridges is also arranged to emit control pulses to the pulse amplifiers 20, 22. Measuring instruments 24, 26 are also arranged to measure the currents  $I_{FB1}$  and  $I_{FB2}$ , respectively, from the current converter bridges 1, 2, and transmit the measured results to the switching logic 18 for control purposes. Connection of the thyristors 8, 10 of the over-voltage protection means is also controlled from the switching logic 18 via the ignition circuits 12, 14. The over-voltage protection means is connected to a current-limiting resistor R. In the system with field breakers this resistor R serves as discharge resistor.

The procedure for switching from bridge 1 to bridge 2 is as follows: Initially bridge 1 is assumed to be conducting, which means that the current direction  $I_F$  through the field winding 4 is positive, see Figures 3a and 3b. The control signal  $U_{st}$ , see Figure 2, to the control pulse generator 28 and the switching logic 18 will be negative, resulting in bias reduction and thus a change of polarity of the bridge 1, see Figure 3a. The time interval for bias change,  $t_2-t_1$  according to Figure 3b, from maximum positive peak voltage to maximum negative peak voltage is approximately 8.3 ms at a frequency of 50 Hz and 6-pulse two-way bridge.

At the time  $t_3$ , when the current  $I_{FB1}$  is still greater than 0, an ignition pulse is transmitted to the discharge thyristor 10 and a blocking signal to the bridge 1. As a result of the free-wheel effect at negative bias, a momentary transmission of excitation current  $I_{FB1}$  to the over-voltage protection circuit is obtained, and the bridge 1 becomes currentless. A signal from the measuring instrument 24 that the bridge 1 is currentless initiates unblocking of bridge 2 and blocking of the ignition circuit 14 for the thyristor 10. The time interval  $t_4-t_3$  according to Figure 3, i.e. the period from the blocking of bridge 1 until the bridge 2 is connected is approximately 5 ms, see Figure 3. It is apparent from Figure 3d that the current  $I_F$  in the field circuit 4 during this switching interval is maintained as a result of the inductance of the field winding 4. As apparent from Figures 3d and 3e, the biased

bridge 2 now forces a current  $I_R$ , see Figure 3f, through the thyristor 10 and the current-limiting resistor R, and also a current  $I_F$  through the field winding 4 of the synchronous machine. At the time  $t_5$  the field current  $I_F$  has changed polarity and the discharge thyristor 10 is extinguished through temporary biasing reduction of the bridge 2, i.e. a temporary change in polarity to force a current in the reverse direction of the short-circuiting circuit or the over-voltage protection means.

A suitable choice of current levels for generating blocking and detecting signals ensures that the time interval is brief for connecting the two-way field over-voltage protection means 8, 10, 12, 14 serving as auxiliary circuit or the two-way thyristor discharge circuit.

Switching from negative current direction to positive current direction at a positive control signal occurs in corresponding manner by temporary connection of the thyristor 8 in the over-voltage protection means.

An embodiment of the rotary electric machine in accordance with the invention is described above by way of example. However, several modifications are of course feasible within the scope of the invention. The principle described can thus be used for both stationary and rotating thyristor bridges for exciting synchronous machines or for supplying motors for drive systems. Temporary or pulsed biasing reduction may also be used to reset an activated over-voltage protection means. In a first phase, an over-voltage signal then gives a signal for alarm and resetting the protection means. A continuous error signal after a number of resetting attempts will generate a tripping signal.

The introduction and use of extinguishable semiconductor elements can also shorten the time interval for switching between positive and negative excitation or vice versa. The introduction of extinguishable semiconductor elements in the two-way over-voltage protection makes temporary reversal of the field voltage unnecessary in order to extinguish an activated and conducting semiconductor element.

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AMENDED CLAIMS

1. A rotary electric machine of alternating current type designed to be connected directly to a distribution or transmission network and comprising at least one electric winding, **characterized** in that the winding comprises at least one electric conductor, a first layer with semiconducting properties surrounding the conductor, a solid insulating layer surrounding the first layer and a second layer with semiconducting properties surrounding the insulating layer, and also in that a brushless excitation system, switchable between positive and negative excitation, is arranged for excitation of the machine.
2. A machine as claimed in claim 1, **characterized** in that the potential on the first layer is substantially equal to the potential on the conductor.
3. A machine as claimed in claim 1 or claim 2, **characterized** in that the second layer is arranged to form a substantially equipotential surface surrounding the conductor.
4. A machine as claimed in claim 3, **characterized** in that the second layer is connected to a predetermined potential.
5. A machine as claimed in claim 4, **characterized** in that said predetermined potential is earth potential.
6. A machine as claimed in any of the preceding claims **characterized** in that at least two adjacent layers of the machine's winding have substantially equally large coefficients of thermal expansion.
7. A machine as claimed in any of the preceding claims **characterized** in that the conductor comprises a number of strands, at least some of which are in electric contact with each other.
8. A machine as claimed in any of the preceding claims, **characterized** in that each of said three layers is firmly joined to adjacent layers along substantially its entire contact surface.
9. A machine as claimed in any of the preceding claims, **characterized** in that said layers are arranged to adhere to each other even when the insulated conductor is bent.

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10. A machine comprising at least one rotary main electric machine of alternating current type designed to be connected directly to a distribution or transmission network and comprising at least one magnetic core and at least one  
5 electric winding, **characterized** in that the winding is formed from a cable comprising one or more current-carrying conductors, each conductor having a number of strands, an inner semiconducting layer arranged around each conductor, an insulating layer of solid insulating material arranged around said inner semiconducting layer, and an outer semiconducting layer arranged around the insulating  
10 layer, and in that a brushless excitation system, switchable between positive and negative excitation, is arranged for excitation of the machine.

11. A machine as claimed in claim 10, **characterized** in that said cable  
15 comprises a metal screen or sheath.

12. A machine as claimed in any of the preceding claims, **characterized** in that the excitation system comprises two controllable antiparallel-connected current converter devices for feeding the field winding (4) of the alternating current machine, a two-way field over-voltage protection means (8, 10, 12, 14) or discharge  
20 circuit connected across the field winding, and control equipment for controlling current converters and field over-voltage protection means or discharge circuit.

13. A machine as claimed in claim 12, **characterized** in that for switching  
25 the direction of the excitation current from the excitation system, the control equipment is arranged to change the polarity of the current converters, the control equipment causing the over-voltage protection means to be temporarily connected at transition from one to the other current direction.

30 14. A machine as claimed in claim 12 or claim 13 **characterized** in that the over-voltage protection means or the discharge circuit comprises a two-way thyristor discharge circuit (8, 10).

15. A machine as claimed in any of claims 12-14, **characterized** in that an  
35 activated over-voltage protection means or discharge circuit can be reset by control of conducting converter devices (1, 2) to temporary or pulse-formed change of polarity.

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16. A machine as claimed in any of claims 12-14, **characterized** in that an activated over-voltage protection means or discharge circuit can be reset by means of extinguishable semiconductor elements.

5 17. An electric power plant, **characterized** in that it comprises a rotary electric machine as claimed in any of claims 1-16.

18. A method of exciting a rotary electric machine as claimed in any of claims 1-16 with both positive and negative excitation current direction, **charac-**  
10 **terized** in that a two-way field over-voltage protection means (8, 10, 12, 14) or a two-way discharge circuit is connected temporarily across the field winding (4) of the machine when switching between excitation current directions.

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Fig. 1

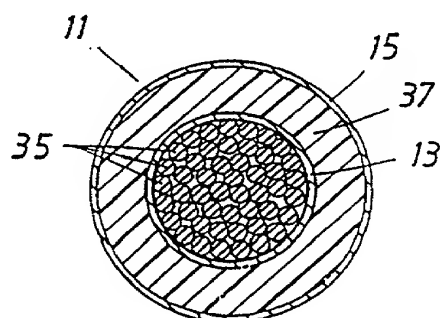
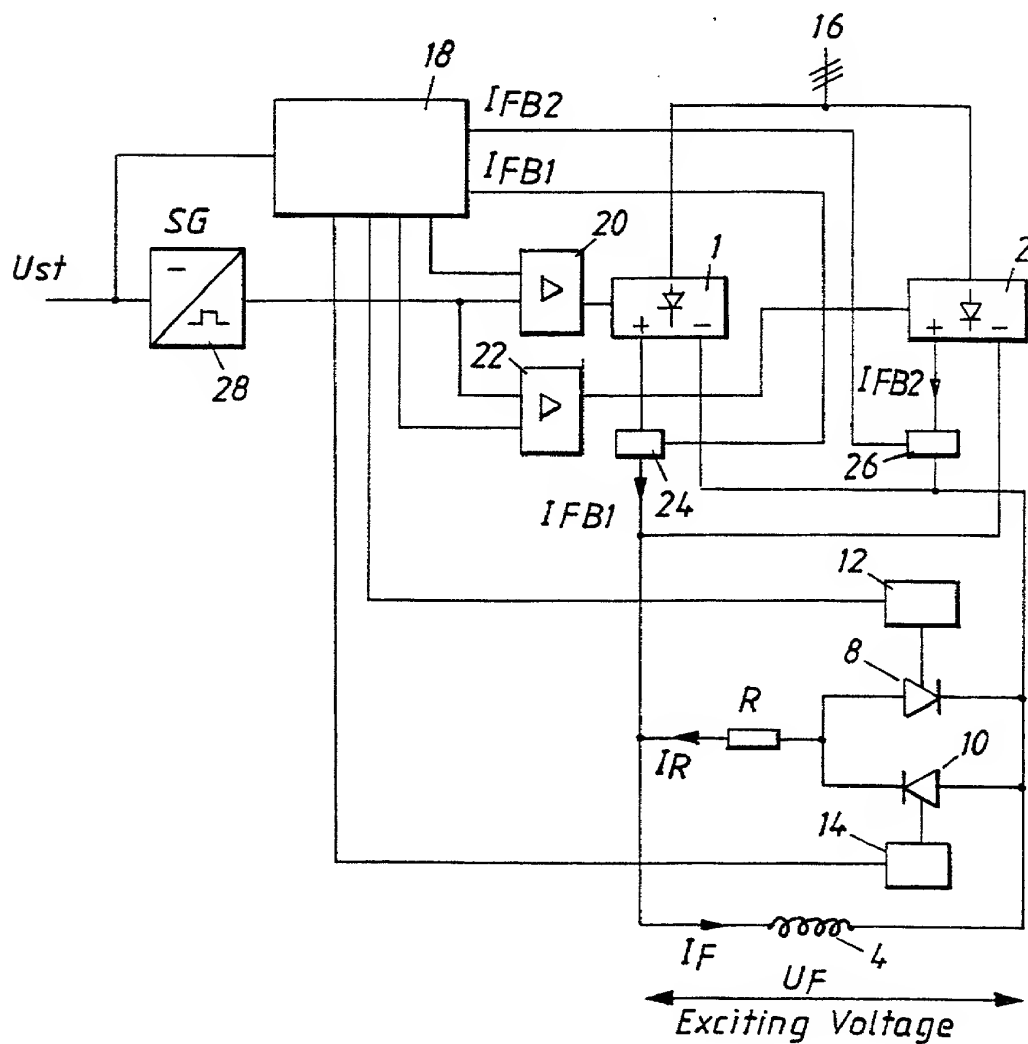
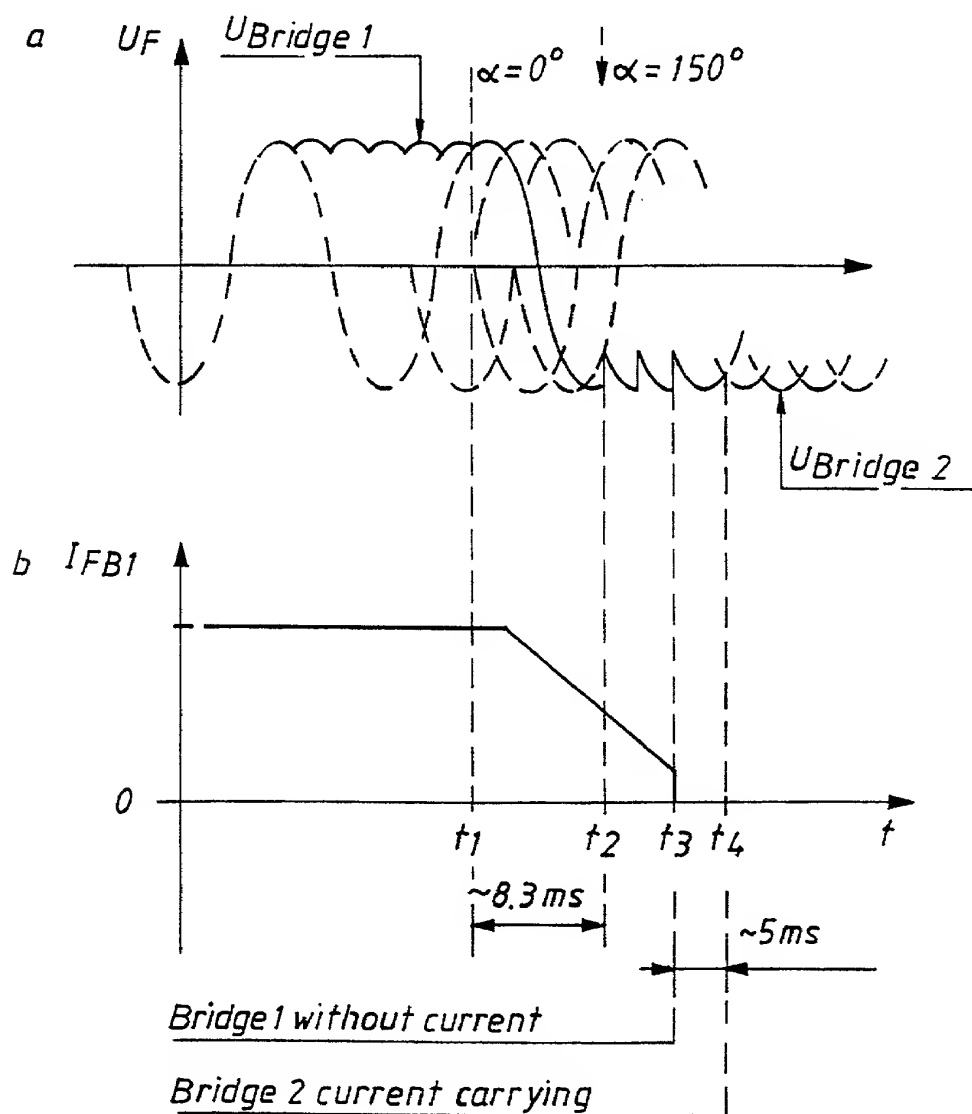


Fig. 2

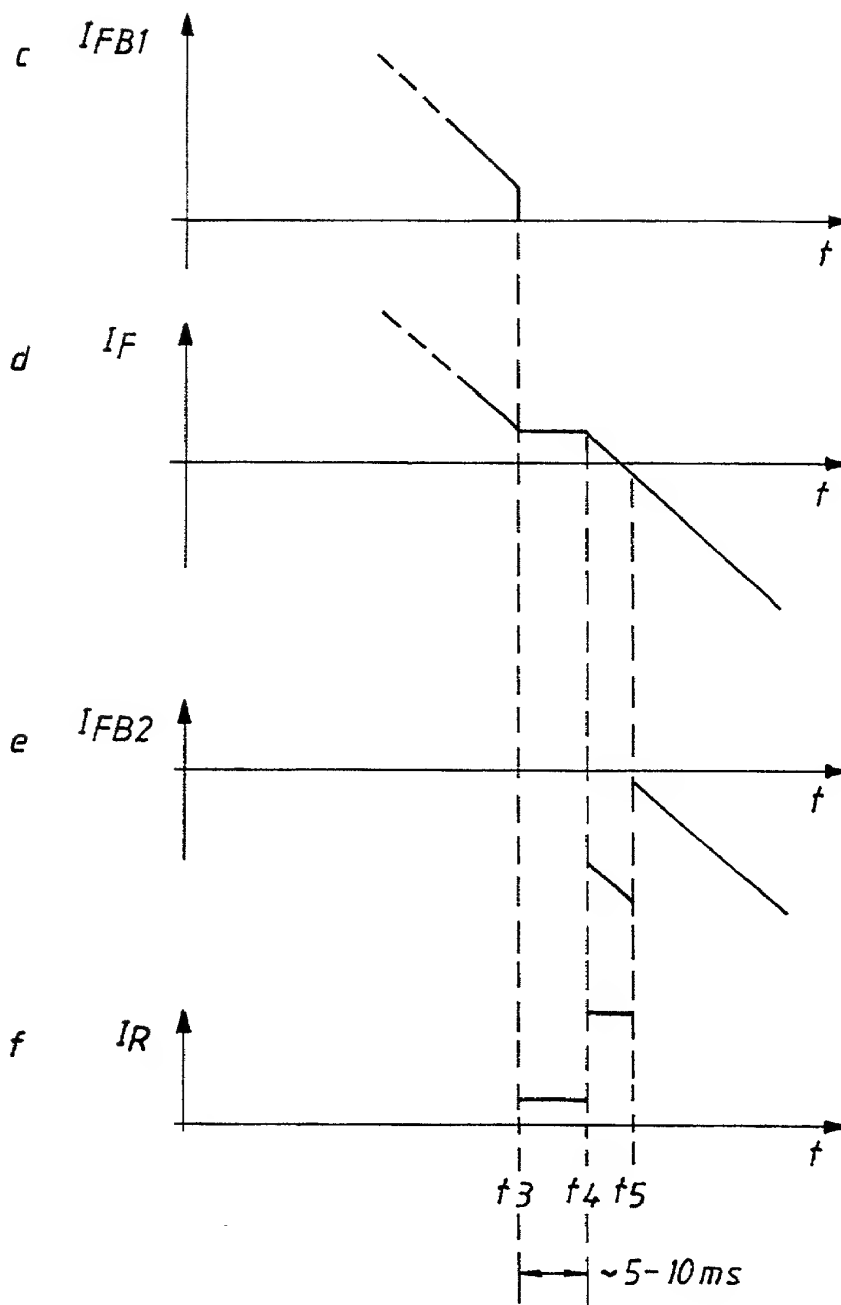


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Fig. 3

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Fig. 3 (contd.)



# Declaration, Power Of Attorney and Petition

Page 1 of 3

WE (I) the undersigned inventor(s), hereby declare(s) that:

My residence, post office address and citizenship are as stated below next to my name,

We (I) believe that we are (I am) the original, first, and joint (sole) inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A ROTARY ELECTRIC MACHINE

the specification of which

☐ is attached hereto.

☒ was filed on March 28, 2000 as  
Application Serial No. 09/508,685  
and amended on \_\_\_\_\_.

☒ was filed as PCT international application  
Number PCT/SE98/01741  
on September 29, 1998,  
and was amended under PCT Article 19  
on \_\_\_\_\_ (if applicable).

We (I) hereby state that we (I) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We (I) acknowledge the duty to disclose information known to be material to the patentability of this application as defined in Section 1.56 of Title 37 Code of Federal Regulations.

We (I) hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed. Prior Foreign Application(s)

Application No.	Country	Day/Month/Year	Priority Claimed
<u>9703555-4</u>	<u>SWEDEN</u>	<u>30 September 1997</u>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No

We (I) hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application Number)

(Filing Date)

(Application Number)

(Filing Date)

We (I) hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.	Filing Date	Status (pending, patented, abandoned)
PCT/SE98/01741	29 September 1998	

And we (I) hereby appoint: Norman F. Oblon, Reg. No. 24,618; Marvin J. Spivak, Reg. No. 24,913; C. Irvin McClelland, Reg. No. 21,124; Gregory J. Maier, Reg. No. 25,599; Arthur I. Neustadt, Reg. No. 24,854; Richard D. Kelly, Reg. No. 27,757; James D. Hamilton, Reg. No. 28,421; Eckhard H. Kuesters, Reg. No. 28,870; Robert T. Pous, Reg. No. 29,099; Charles L. Gholz, Reg. No. 26,395; Vincent J. Sunderdick, Reg. No. 29,004; William E. Beaumont, Reg. No. 30,996; Robert F. Gnuse, Reg. No. 27,295; Jean-Paul Lavalleye, Reg. No. 31,451; Stephen G. Baxter, Reg. No. 32,884; Robert W. Hahl, Reg. No. 33,893; Richard L. Treanor, Reg. No. 36,379; Steven P. Weihrouch, Reg. No. 32,829; John T. Goolkasian, Reg. No. 26,142; Richard L. Chinn, Reg. No. 34,305; Steven E. Lipman, Reg. No. 30,011; Carl E. Schlier, Reg. No. 34,426; James J. Kulbaski, Reg. No. 34,648; Richard A. Neifeld, Reg. No. 35,299; J. Derek Mason, Reg. No. 35,270; Surinder Sachar, Reg. No. 34,423; Christina M. Gadiano, Reg. No. 37,628; Jeffrey B. McIntyre, Reg. No. 36,867; Paul E. Rauch, Reg. No. 38,591; William T. Enos, Reg. No. 33,128; and Michael E. McCabe, Jr., Reg. No. 37,182; our (my) attorneys, with full powers of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith; and we (I) hereby request that all correspondence regarding this application be sent to the firm of OBLON, SPIVAK, McCLELLAND, MAIER & NEUSTADT, P.C., whose Post Office Address is: Fourth Floor, 1755 Jefferson Davis Highway, Arlington, Virginia 22202.

We (I) declare that all statements made herein of our (my) own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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19 May 2000

Date

NAME OF THIRD JOINT INVENTOR

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